Ministry of
Northern Development
and Mines

Ontario

Mines and Minerals Division
Ontario Geological Survey

Open File Map 198

Paleo[illegible] Geology

Northern Bruce Peninsula

Southern Ontario

Scale 1:50 000

1000 m 0 1 2 km

UNEDITED MANUSCRIPT

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Armstrong, D.K. and Dubord, M.P. 1992. Paleozoic geology, northern Bruce Peninsula, southern Ontario; Ontario Geological Survey, Open File Map 198, scale 1:50 000.

LEGEND

PALEOZOIC

SILURIAN

10 Guelph Formation

10d Lithofacies G_d: Biohermal dolostone; light grey-tan to tan, fossiliferous, irregularly to lensoidal bedded; may include outcrops of other Guelph lithofacies.

10c Lithofacies G_c: Dolostone; light grey-tan to brown, tabular bedded; locally biostromal.

Eramosa Member

10b Lithofacies G_b: Dolostone; slightly to moderately bituminous, light tan to grey-tan, microstylolites, local chert.

10a Lithofacies G_a: Dolostone; laminated, moderately to very bituminous, local minor chert; interbeds of lithofacies G_b are common.

9 Amabel Formation

Wiarton/Colpoy Bay Member

9c Lithofacies A_c: Biohermal dolostone; fossiliferous, white to light grey-tan, irregular blue-grey mottles, thick- to massive-bedded, undulatory to lensoidal bedding.

9b Lithofacies A_b: Dolostone; white to light grey-tan, streaky blue-grey mottles, thick- to massive-bedded.

Lions Head Member

9a Lithofacies A_a: Dolostone; light grey-tan, thin- to thick-bedded, dense, sparsely fossiliferous; local blue to purple mottles, chert nodules and microstylolites.

8 Fossil Hill Formation: Dolostone; fossiliferous; fauna commonly silicified; local chert nodules; micro-crystalline, non-fossiliferous, beds in middle.

7 St. Edmund Formation: Dolostone; thin-bedded, micro- to fine-crystalline, non- to moderately fossiliferous; with minor grey-green shale interbeds.

6 Wingfield Formation: Interbedded dolostone and shale; dolostone is thin-bedded; shale is grey-green.

5 Dyer Bay Formation: Dolostone; light grey to dark grey-brown, thin- to medium-bedded, moderately fossiliferous, abundant sedimentary structures.

4 Cabot Head Formation: Shale; red and minor grey-green, siliciclastic; with minor dolostone interbeds.

3 Manitoulin Formation: Dolostone and calcareous dolostone; thin- to thick-bedded, fine- to coarse crystalline; local small bioherms.

ORDOVICIAN

2 Queenston Formation: Shale; red and grey-green, siliciclastic.

1* Georgian Bay Formation*: Interbedded shale, limestone and calcareous siltstone.

* Not present in this map area.

SYMBOLS

x Bedrock outcrop

Drill hole site

Zn Zinc sulphide (sphalerite) occurrence

Geological boundary, observed

Geological boundary, approximate

Geological boundary, interpreted

SOURCES OF INFORMATION

Topography from Map 41 H/3, 4, 5 of the National Topographic System.

Records of petroleum exploration wells from the Ministry of Natural Resources, Petroleum Resources Laboratory, London.

Metric conversion factor: 1 foot = 0.3048 m

CREDITS

Geology by D.K. Armstrong and M.P. Dubord, 1987. Additional geological information from OGS drill holes OGS-89-2, OGS-89-3, and OGS-90-1.

Every possible effort has been made to ensure the accuracy of the information presented in this map; however, the Ontario Ministry of Northern Development and Mines does not assume any liability for errors that may occur. Users may wish to verify critical information; sources include both the references listed here and information on file at the Resident or Regional Geologist's office and the Mining Recorder's office nearest the map area.

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PALEOZOIC GEOLOGY OF THE NORTHERN BRUCE PENINSULA

MARGINAL NOTES

INTRODUCTION

Regional mapping by the Ontario Geological Survey (OGS) of the exposed Paleozoic strata on the Bruce Peninsula commenced in 1987 with mapping of the northern portion of the peninsula, north of latitude 45o00'N (this map). This was followed, in subsequent years, with mapping of the central and southern portions of the peninsula (OFM maps #___ and #___).

The northern Bruce Peninsula map area is covered by 1:50,000 scale N.T.S. map sheets Dyer's Bay (41H/3) and Dorcas Bay (41H/4), and the southernmost (i.e. mainland) portion of the Flowerpot Island map sheet (41H/5). The Bruce Peninsula can be accessed by King's Highway 6, via Owen Sound and Wiarton. Public and private, paved and gravel roads provide good access in much of the map area. Access to some of the more remote regions in the map area are afforded by the Bruce Trail, numerous other trails and abandoned roads. A significant portion of northern part of the map area is within the boundaries of the newly created Bruce Peninsula National Park.

Subsurface information in the northern Bruce Peninsula map area is afforded by drill cuttings and geophysical logs from three petroleum exploration wells drilled (see map for locations) to Precambrian basement during the 1950's. In the 1980's the OGS drilled a series of deep regional drill holes in southern Ontario. These holes were continuously cored and geophysically logged through the Paleozoic succession to Precambrian basement (see Johnson et al. 1985). The nearest of these deep drill holes to the north Bruce Peninsula map area, drillhole OGS-82-4, is located 6 km northwest of Wiarton, approximately 24 km south of this map area. In 1989 and 1990, the OGS cored a series of relatively shallow (35 to 123 m deep) drill holes on the Bruce Peninsula in support of the present mapping project. Preliminary results were reported by Armstrong (1989) and are incorporated in these marginal notes. Detailed core descriptions and geophysical logs will be published in a future open file report (Armstrong in prep.).

STRATIGRAPHY

The exposed Paleozoic strata of the Bruce Peninsula have been studied and mapped by a succession of geologists since the turn of this century. Although the resultant geological maps (Williams 1919; Caley 1945; Liberty 1966; Liberty and Bolton 1971) are generally consistent in their delineation of most formational contacts, there are significant exceptions,

especially of the two youngest formations (the Amabel and Guelph formations). Additionally, numerous reports have been written on the stratigraphy, paleontology, and depositional histories of the Silurian strata of the Bruce Peninsula (Williams 1919; Bolton 1953; Bolton 1957; Sanford 1969; Liberty and Bolton 1971). Owing to its accessibility and relatively good bedrock exposure, the Silurian strata of the Bruce Peninsula have also been the subject of a number of geological field trips (eg. Winder and Sanford 1972; Telford 1978; Armstrong and Goodman 1990).

The northern Bruce Peninsula is underlain by up to 500 m of Paleozoic strata, however less than 170 m (stratigraphic thickness) of these strata, ranging from Upper Ordovician to Middle Silurian in age, are exposed.

ORDOVICIAN

Queenston Formation

The oldest strata exposed on the northern Bruce Peninsula are the grey-green and red siliciclastic shales of the Upper Ordovician Queenston Formation. These recessively weathering shales are poorly exposed along the shoreline of Cabot Head, the northeast point of the peninsula. There, they underlie a low escarpment of Manitoulin Formation dolostones.

The uppermost 1 to 2 m of the Queenston Formation are commonly grey-green in colour. Scattered outcrops of red shale in the boulder beach at Cabot Head indicate a colour change to red within a few metres of the upper contact.

The talus and boulder/cobble covered slope beneath the low Manitoulin Formation escarpment at the lighthouse at Cabot Head indicates that the maximum exposed thickness of the Queenston Formation on the northern Bruce Peninsula is no more than 6 m. In the subsurface of the map area, up to 60 m of Queenston Formation were encountered petroleum exploration wells. The cuttings from these wells indicate that, in the northern Bruce Peninsula area, this formation contains significantly more carbonate interbeds and is dominantly grey in colour, as compared with its character further to the south (Liberty and Bolton 1971).

SILURIAN

Manitoulin Formation

The Lower Silurian Manitoulin Formation is only exposed in the northeast corner of this map area, where it forms a small escarpment (<10 m high) and plateau below and east of the main Niagara Escarpment at Cabot Head. The Manitoulin Formation consists of thin- to thick-bedded, light grey-brown to blue-grey, buff brown weathering dolostones and calcareous dolostones, which disconformably overlie grey-green shales of the Queenston

Formation. This contact, which is best exposed along the shore of Cabot Head, east of Boulder Bluff, is sharp. Grey-green shale lithoclasts and partings occur in the basal, approximately 10 cm, of the Manitoulin Formation and gutter casts, up to 1 m wide, cut up to 10 cm into the underlying Queenston Formation.

In the Cabot Head area, the Manitoulin Formation can be grossly subdivided into two informal units: a lower medium- to thick-bedded, medium- to coarse-crystalline dolostone which is commonly planar laminated or cross-stratified and an upper, thin-bedded, bioturbated, fossiliferous, fine- to medium-crystalline dolostone (Anastas 1992). In this area small (2 to 5 m in diameter by 0.5 to 1.5 m thick) bryozoan-dominated bioherms occur mainly in the upper unit, at the base of the formation and occasionally within the lower unit (Anastas and Coniglio, in press).

The upper contact of the Manitoulin Formation is nowhere exposed in the map area. Outcrops at Cabot Head indicate that the formation is at least 4.5 m thick there. Reported thicknesses (petroleum exploration wells) for this unit in the subsurface of the map area range from 5.5 to 7.6 m.

Cabot Head Formation

On the northern Bruce Peninsula, the Lower Silurian Cabot Head Formation (the Cabot Head (restricted) Member of Liberty and Bolton, 1971) consists primarily of red, siliciclastic shales. It is best exposed at its type section, in the cliff at Rocky Bay, on the north shore of the peninsula, 4.5 km west of Cabot Head. It is also partially exposed in scattered outcrops at the base of the escarpment along the road from Dyer's Bay to Cabot Head, in the vicinity of Cape Chin, and on the Lion's Head promontory at Lion's Head Point and Gun Point. Because of its shaly nature the Cabot Head Formation weathers recessively and generally occurs under talus covered and vegetated slopes. Owing to its narrow outcrop belt and the scale of this map, this unit is locally combined with one or more of the relatively thin overlying units.

The lower contact of the Cabot Head Formation is not exposed in this map area. Its upper contact, as exposed in outcrops at Rocky Bay, Cape Chin and Lion's Head Point, is sharp. Although predominantly a red shale in this area, minor thin green shale beds and rare thin dolostone beds are observed in outcrop. The uppermost 1 to 2 m of this formation is also commonly green in colour.

The thickest exposed interval of this unit in the map area, approximately 15 m, is at Rocky Bay. Approximately 9 m of the Cabot Head Formation is exposed along the shore at Gun Point. Subsurface information from petroleum exploration wells in the map area indicate an approximate total thickness of up to 34.5 m.

Dyer Bay Formation

The dolostones of the Middle Silurian Dyer Bay Formation form a low, intermittently developed escarpment along the east shore of the Bruce Peninsula, in the vicinity of Dyer's Bay, Cape Chin and at Lion's Head Point. This formation is also exposed in low outcrops near the shoreline at Dyer's Bay, its type locality (Liberty and Bolton 1971). The entire unit, complete with upper and lower contacts, is exposed in the cliff at Rocky Bay.

The Dyer Bay Formation consists of thin- to medium-bedded, light grey to dark grey-brown, microcrystalline to coarse-crystalline dolostone. The basal 1 m is commonly microcrystalline. This formation typically exhibits platy, planar to slightly irregular parting and very regular, vertical jointing.

The Dyer Bay Formation is moderately to highly fossiliferous. The fauna is dominated by bryozoans and also contains various corals, brachiopods, and few gastropods. Trace fossils are abundant. The formation also contains various non-biogenic sedimentary structures such as soft-sediment slumps, scour marks, ripplemarks, and rip-up lithoclasts.

In outcrop the lower contact of the Dyer Bay Formation is sharp and appears disconformable. However, in drill hole OGS-90-1, located in the southern part of the map area, burrows appear to extend into the underlying Cabot Head Formation. The Dyer Bay Formation averages 4 to 5 m in thickness in the map area, although thicknesses of up to 10 m in the subsurface are reported in petroleum exploration well records. Drill hole OGS-90-1 intersected the entire formation, a total thickness of 4.78 m.

Wingfield Formation

The Middle Silurian Wingfield Formation consists of interbedded dolostone and shale. Although dominantly dolostone, its thin shale interbeds predispose this unit to recessive weathering. It is poorly exposed along the shores of Dyer's Bay, Cape Chin and Isthmus Bay. A complete interval can be examined in the cliff exposure at Rocky Bay, its type section.

The Wingfield Formation consists of thin interbeds of grey-brown, fine- to medium-crystalline dolostone with grey-green shale lithoclasts and partings. The dolostone beds are locally laminated, and ripplemarks and mudcracks are common. The interbedded shale is grey-green in colour.

The lower and upper gradational contacts of the Wingfield Formation, best exposed at Rocky Bay, are taken at the lowermost and uppermost significant occurrence of grey-green shale between the Dyer Bay and St. Edmund Formations, respectively. The Wingfield Formation is approximately 10 m thick at Rocky Bay. Reported thicknesses in the subsurface range from 2.7 to 10 m.

The entire formation was cored in drill hole OGS-90-1, where its thickness was 11.73 m.

St. Edmund Formation

The Middle Silurian St. Edmund Formation is a thin-bedded, buff-tan weathering dolostone unit, locally capped by a thin zone containing grey-green shale interbeds. It is best exposed (although partly covered) at its type section, at Rocky Bay, on the north shore of the Bruce Peninsula, 4.5 km west of Cabot Head. It is also partly exposed at Boulder Bluff, on the south side of Cabot Head, and at or near the shoreline in the Dyer's Bay vicinity.

The St. Edmund Formation consists mainly of light grey-brown to grey-brown, microcrystalline to fine-crystalline, sparsely to moderately fossiliferous dolostone. It is typically platy to blocky, planar to irregularly parted. Bioturbation is indicated in some microcrystalline (mudstone) beds by irregular to nodular parting. Locally abundant fossils include corals and brachiopods.

In the Cabot Head area, the uppermost 1 to 2 m of the St. Edmund Formation consists of interbedded grey-green shale and microcrystalline dolostone and the uppermost 0.5 to 1 m consists of thin-bedded microcrystalline dolostone. An almost identical succession was encountered in drill hole OGS-89-2, drilled approximately 20 km to the southwest (Armstrong, in prep.). To the northwest, drill hole OGS-89-3 encountered 8.38 m of dolostones assignable to the St. Edmund Formation with no interbedded shales.

The St. Edmund Formation is approximately 4.25 m thick at Rocky Bay. This formation is progressively cut by an unconformity at the base of the overlying Fossil Hill Formation, such that it was not observed in outcrop south of Cape Chin. In the subsurface, only 1.02 m of the St. Edmund Formation was encountered in OGS-90-1 and it was not encountered in drill hole OGS-89-1, drilled approximately 12.5 km south of this map area (Armstrong, in prep.).

Fossil Hill Formation

The Middle Silurian Fossil Hill Formation consists primarily of thin- to medium-bedded fossiliferous dolostone and commonly occurs in the northern Bruce Peninsula map area as a subordinate escarpment below the main Niagara Escarpment. The complete Fossil Hill Formation interval is exposed at Boulder Bluff, southwest of Cabot Head. Other good exposures exist at Rocky Bay, north and south Dyer's Bay, Whippoorwill Bay, McKay's Harbour and in extensive bedding plane outcrops along the shores of Isthmus and Whippoorwill bays.

The Fossil Hill Formation consists of thin- to medium-bedded, light to dark brown, fine- to coarse-crystalline, fossiliferous dolostone with an abundant and commonly silicified fauna. The fauna is dominated by pentamerid brachiopods and contains locally significant corals (syringoporid, halysitid, and favositid types) and stromatoporoids (Johnson 1979). In the southern part of the map area the middle third of the formation consists of very fine- to microcrystalline, bioturbated, non-fossiliferous dolostone which is informally referred to as the "barren beds" or "barren zone". This "barren zone" thins significantly to the north and does not appear to be present in outcrops north of Cape Chin. In the subsurface the "barren zone" ranges from 2.87 m thick in drillhole OGS-90-1, north of Stokes Bay, to 1 m thick in OGS-89-3, near Tobermory.

Regionally, the basal contact of the Fossil Hill Formation is an angular unconformity cutting progressively older units in a southwardly direction. In its outcrop belt, this formation sharply overlies microcrystalline dolostone of the St. Edmund Formation at Rocky Bay and to the south sharply overlies grey-green shales and interbedded dolostones of the Wingfield Formation at Isthmus Bay. The basal contact of the Fossil Hill Formation was encountered in all three OGS drill holes in the map area (see Armstrong, in prep.).

The Fossil Hill Formation ranges from approximately 7 m thick in the Lion's Head and Cabot Head areas to less than 4 m thick north of Cape Chin. In the subsurface of the map area this formation thins northwardly from 5.08 m thick in drill hole OGS-90-1 to 2.72 m thick in OGS-89-3.

Amabel Formation

On the Bruce Peninsula the Amabel Formation is stratigraphically subdivided into a lower unit, the Lions Head Member and an upper unit, the Wiarton/Colpoy Bay Member. In the map area the Wiarton/Colpoy Bay Member grades laterally to the Lions Head Member, such that in the northwest part of the map area the Lions Head Member constitutes the entire Amabel Formation.

In this study the Amabel Formation is subdivided into three lithofacies: lithofacies A_a corresponds directly to the Lions Head Member, and lithofacies A_b and A_c correspond to the non-biohermal and biohermal lithofacies of the Wiarton/Colpoy Bay Member, respectively. Lithofacies A_a occurs at the base of the formation, however, along the northern shore of the peninsula, and in the subsurface in the northwest of the map area, it constitutes the entire formation. Lithofacies A_b makes up most of the remainder of the formation (i.e. the Wiarton/Colpoy Bay Member), especially in the southern part of the map area. Lithofacies A_c is developed only locally in the map area, generally in the upper third of the Wiarton/Colpoy Bay Member.

The **Lions Head Member**, or **lithofacies A_a**, consists of light grey-tan, thin- to thick-bedded, platy to blocky parted, fine-crystalline, dense, non- to sparsely fossiliferous dolostone with locally significant blue to purple mottles, chert nodules and microstylolites. The sparse fauna, which include corals, stromatoporoids, and crinoids, are commonly broken and silicified. Mottles are typically distinct and range from sparse, small, burrow-like shapes to more intense swirly forms. Thin blue beds with sharp upper contacts (possibly hard grounds?) occur locally near the base of this member.

The basal contact of the Lions Head Member with the underlying Fossil Hill Formation is not well exposed in the map area. Even in almost completely exposed sections, such as at Boulder Bluff, the contact weathers recessively. In drill core this contact is sharp and appears to be disconformable, locally marked by the presence of glauconite and/or pyrite (Armstrong in prep.).

Despite intense dolomitization which has tended to obscure fossil content and primary sedimentary structures in the **Wiarton/Colpoy Bay Member**, two gross lithofacies have been identified constituting this unit: the non-biohermal lithofacies A_b and the biohermal lithofacies A_c. Both of these lithofacies are very thick-bedded, white-weathering dolostones which form the main cliffs of the Niagara Escarpment. They are differentiated on the basis of apparent fossil content and related porosity, bedding morphology, weathering characteristic and, locally, mottling style and intensity.

Lithofacies A_b consists of white to light grey-tan, blue-grey mottled, fine- to medium-crystalline, thick- to massive-bedded, sparsely to very fossiliferous dolostone. Porosity in this lithofacies ranges from nonexistent in local intervals to local fossil moldic or vuggy porosity. A moderately to well developed, fine, inter-crystalline porosity is common in this lithofacies. This lithofacies appears to consist mainly of sand-sized crinoidal fragments. Locally identifiable fossils include crinoids, corals (rugose and tabulate), cephalopods and brachiopods. The characteristic streaky, diffuse, blue-grey mottling and related(?) ribbed pattern, exhibited on weathered vertical faces (i.e., on dissolution enhanced joint surfaces), appear to indicate primary bedding and locally are suggestive of cross-stratification.

Lithofacies A_b generally overlies lithofacies A_a gradationally. Locally, however, coarser lithofacies A_b beds sharply overlie lithofacies A_a or interbeds of one lithofacies occur within the other. Regionally, to the north and northwest, lithofacies A_b grades laterally into lithofacies A_a. Lithofacies A_a is interpreted to be a deeper water facies equivalent of lithofacies A_b.

Lithofacies A_c is lithologically similar to lithofacies A_b except that it tends to have a more intense blue-grey mottling and be coarser crystalline. The fauna, essentially the same as in lithofacies A_b, tend to be more obvious, larger and rimmed by blue-grey colouration in lithofacies A_c. Also, bedding tends to be more lensoidal or undulatory than in lithofacies A_b. In addition, lithofacies A_c tends to weather more ruggedly than lithofacies A_b; the latter weathers into relatively smooth, large, jointed blocks. These characteristics are consistent with a biohermal origin for lithofacies A_c. Small lenses, a few metres across, of lithofacies A_c occur locally in lithofacies A_b and are not indicated on the map. Zones of dense, fine-crystalline, locally vuggy, irregularly blue mottled dolostone, encountered in drill core (e.g. in OGS-89-2), may be small mud-dominated lenses of lithofacies A_c (i.e. mudmounds).

Large northwest trending dolostone ridges, within the middle to upper part of the Amabel Formation, occur in this map area on the Lion's Head promontory. These ridges are in the order of 10's of metres wide by 100's of metres long and up to a few metres high. Although these ridges commonly contain undulatory bedding, other lithofacies A_c characteristics are not always obvious and a biohermal origin is speculative. An alternate explanation for their origin is that they are large sand bodies, composed of lithofacies A_b, which were formed by currents. They possibly formed the foundation for lithofacies A_c bioherms or younger Guelph Formation bioherms.

In this map area, lithofacies A_c is best developed in the Forty Hills area. There, it is dominantly crinoidal and directly underlies the tan coloured biohermal lithofacies G_d of the Guelph Formation. This contact appears to be gradational in outcrop and in the subsurface, as indicated in drill hole OGS-90-1 (Armstrong in prep.). Lithofacies A_c also occurs near the top of the Amabel Formation at the north end of the Bruce Peninsula, in the Cabot Head to Umbrella Lake area.

The upper contact of the Amabel Formation in the map area, in both biohermal and non-biohermal situations, is generally gradational. Locally, such as in the Brinkman's Corners to Cape Chin area, interbeds of Guelph Formation lithofacies (tan, fine-crystalline dolostone) occur within the uppermost Amabel Formation. Locally, the top of the Wiarton/Colpoy Bay Member is sharp and stylolitized.

A complete interval of the Amabel Formation is not exposed in a single outcrop in the map area. In the subsurface of the northern Bruce Peninsula this formation thickens from approximately 17 m in the northwest to over 25 m in the south (Armstrong in prep.).

Guelph Formation

In this study, four lithofacies are identified constituting the Guelph Formation. Two lithofacies, G_a and G_b, correspond to the strata assigned to the Eramosa Member (previously of the Amabel Formation). The remainder of the Guelph Formation consists of the non-biohermal lithofacies G_c and the biohermal lithofacies G_d. Lithofacies G_a and G_b (i.e. the Eramosa Member) occupy an inter-biohermal position in the lower part of the formation and are absent where Guelph biohermal complexes directly overlie Amabel bioherms. The bioherms of lithofacies G_d occur at various stratigraphic positions in the formation: underlying, overlying and lateral to the Eramosa Member lithofacies. Lithofacies G_c occurs throughout the Guelph Formation, overlying and grading laterally into lithofacies G_d and overlying lithofacies G_a and G_b where they are present.

The **Eramosa Member**, consisting generally of thin-bedded, bituminous dolostone, can be subdivided into two lithofacies, G_a and G_b. **Lithofacies G_a** consists of tan-grey to black, very fine- to medium-crystalline, thin- to medium-bedded, sparsely fossiliferous, moderately to very bituminous, laminated dolostone with minor local chert nodules. Interbeds of non-laminated, slightly bituminous lithofacies G_b dolostone are common. Fauna, including brachiopods and corals, are typically small and sparse. Also, the laminae may in part be algal in origin. Lithofacies G_a occurs in three locations in the map area: Driftwood Cove on the north shore, George and Marley lakes, and east of Miller Lake. More widespread occurrences of lithofacies G_b in the map area suggest that lithofacies G_a may also be more extensive.

Lithofacies G_b consists of light tan to grey-tan, thin- to thick-bedded, sparsely fossiliferous, slightly to moderately bituminous dolostone with sparse to abundant microstylolites and local chert. This lithofacies is commonly interbedded with lithofacies G_a and is transitional in character between lithofacies G_a and lithofacies G_c. The contact between lithofacies G_b and G_c is typically gradational. Lithofacies G_b occurs mainly in the central part of the outcrop belt, between George Lake and Miller Lake. Other occurrences in the map area include Cyprus Lake in the north and Stokes Bay in the south.

Lithofacies G_c comprises the bulk of the Guelph Formation on the Bruce Peninsula. This lithofacies consists of light grey-tan to brown, fine- to medium-crystalline, thin- to thick-bedded, sparsely to very fossiliferous dolostone. It is typically tabular bedded and beds are horizontally oriented, except where they drape over bioherms of lithofacies G_d.

Fauna include bivalves, gastropods, brachiopods, cephalopods, corals, stromatoporoids, and crinoids. These fauna are locally concentrated into biostromal horizons or into small (<3 m diameter) biohermal mounds; both of these are included within this lithofacies. Molds of the large bivalve Megalomus

canadensis occur in an outcrop on Highway 6, at the turn-off to Cyprus Lake.

Porosity types range from fine inter-crystalline to large fossil moldic and vuggy. A small "wormy" porosity is locally developed. This is especially evident in the Tobermory area, near the stratigraphically highest part of the Guelph Formation on the peninsula. The origin of this porosity type is uncertain, however locally, "wormey" pores appear to be developed between large (up to 5 cm in diameter) crystal/particle aggregates (possibly pisolites?).

On a weathered surface, lithofacies G_c commonly exhibits a course ribbing (centimetre to decimetre scale) which corresponds to interbeds of softer, more porous (and more fossiliferous?) dolostone and more resistant, less porous beds. Locally the non-porous beds appear laminated. As with the Amabel Formation, dolomitization has obscured much of the primary structures and fossil content in the Guelph Formation.

Locally, lithofacies G_c exhibits minor blue-grey mottling. Blue colouration also occurs locally in beds associated with possible pisolites or with possible hardground development and rimming fossils.

Generally, lithofacies G_c gradationally overlies lithofacies G_b or Amabel Formation lithofacies A_b. Lithofacies G_c also grades laterally into flank beds of lithofacies G_d. Non-horizontal lithofacies G_c beds are interpreted as draping over lithofacies G_d bioherms.

Lithofacies G_d consists of light grey-tan to tan, locally blue-grey mottled, medium- to very coarse-crystalline, thin- to thick-bedded, irregular to lensoidal bedded, fossiliferous dolostone. This lithofacies is interpreted to be biohermal in origin. The contained fauna are essentially the same as in lithofacies G_c, however they are more abundant and larger, frame-builders (corals and stromatoporoids) predominate, and they are commonly concentrated in type-specific zones. Very coarse crinoidal grainstones are common in the lower and flanking parts of these bioherms.

Areas designated on the map as being underlain by lithofacies G_d commonly include a number of individual bioherms and intervening areas with outcrops of lithofacies G_b or G_c. Beds of these latter lithofacies are commonly oriented sub-horizontal, as they dip off or flank the bioherms.

Blue-grey colouration, either as mottles or rimming fossils is similar to that seen exhibited by the Amabel Formation biohermal lithofacies A_c. In addition, the commonly thick and lensoidal bedding of lithofacies G_d is also similar to that of the Amabel Formation. Where Guelph Formation bioherms directly overlie Amabel Formation lithofacies A_c, such as in the Forty

Hills to Stokes Bay area, the similarities in lithologic character complicate the placement of the formational contact. Bioherms which occur stratigraphically low in the Guelph Formation or high in the Amabel Formation and in isolation (i.e. without associated flanking beds) are commonly difficult to assign to either formation.

There are two main areas of biohermal development in the Guelph Formation in the map area: in the Forty Hills to Stokes Bay area, and along the north shore, from Cyprus Lake to Tobermory. These two areas probably represent large biohermal complexes. Other bioherms occur north of Moore Lake, near Brinkman's Corners, and south of Miller Lake. The latter bioherms, south of Miller Lake, form northwest oriented ridges similar in style to those identified as Guelph Formation bioherms along Highway 6 west of Hope Bay (Armstrong and Goodman 1990). Among the best exposures of lithofacies G_d bioherms on the Bruce Peninsula, are those in road cuts along Highway 6, in the Forty Hills-Stokes Bay biohermal complex.

There is no single outcrop in the map area which exposes the entire thickness of the Guelph Formation. The thickest Guelph Formation interval intersected in OGS drill holes on the Bruce Peninsula is 88.87 m in OGS-89-3, at Tobermory. The lowest 24.54 m of this interval consists of lithofacies G_b and is assigned to the Eramosa Member.

ECONOMIC GEOLOGY

Building stone has been quarried from the Amabel and Guelph formations since before the turn of the century (Parks 1912; Goudge 1938). The Wiarton/Colpoy Bay Member of the Amabel Formation is currently quarried for aggregate and dimension stone products at quarries in the southern and central Bruce Peninsula (Derry Michener Booth and Wahl and Ontario Geological Survey 1989). The Eramosa Member of the Guelph Formation is currently quarried for a variety of building stone products from numerous quarries in the southern and central Bruce Peninsula (Armstrong and Meadows 1987). Except for a small, long abandoned building stone quarry in the Guelph Formation, located just north of Cape Chin (Liberty and Bolton 1971; Caley 1945), no large scale quarrying has been undertaken in the northern Bruce Peninsula.

Potential exists for thin-bedded building and landscaping stone products from the Eramosa Member in the Marley and George lakes area, aggregate or thicker-bedded building stone products from the Amabel Formation on the eastern side of the peninsula and the non-biohermal lithofacies of the Guelph Formation in the central and western parts. Development is restricted on the eastern side of the peninsula by the Niagara Escarpment Plan and in much of St. Edmund Township by the newly created Bruce Peninsula National Park.

The Ontario Geological Survey recently conducted an evaluation of aggregate resources in St. Edmund and Lindsay townships (OGS, in prep). Aggregate quality tests conducted by the Ministry of Transportation of Ontario (MTO) for this evaluation are generally favourable for outcrop samples of the Guelph and Amabel formations.

Potential shale resources are very limited in the northern Bruce Peninsula as the shale units (i.e. Queenston and Cabot Head formations) are poorly exposed in a narrow outcrop belt at the base of the Niagara Escarpment.

The Guelph and Amabel formations are host to a number of zinc sulphide occurrences (Liberty and Bolton 1971; Tworo 1985) which have been extensively investigated since the early part of this century (Williams 1991; Guillet 1967). None of these occurrences were ever developed into economic deposits. In the northern Bruce Peninsula sphalerite occurs as open space fillings (in fossil molds, vugs and fractures) in the biohermal lithofacies of the Guelph and/or Amabel formations northwest of Umbrella Lake. This occurrence is now located within the Bruce Peninsula National Park.

The only hydrocarbon-producing field on the Bruce Peninsula is the now-abandoned natural gas field at Hepworth, in the southern part of the peninsula. This field produced gas from the Ordovician Simcoe Group (or Trenton-Black River) at a depth of approximately 427 m, from 1901 to approximately 1935 (Bailey and Cochrane 1984). The most recent petroleum exploration activity in the northern Bruce Peninsula occurred during the 1950's. Three wells, at Tobermory, Brinkman's Corners and Miller Lake, were bored to Precambrian basement, which was encountered at depths ranging from 434 m to 491 m. No oil or gas shows were reported in these wells.

KARST

The carbonate bedrock surface of the Bruce Peninsula has been exposed to the dissolution action of water owing to its relatively thin drift cover. Karst features and processes were described by Cowell (1976) and Cowell and Ford (1980). Karst pavement has developed on the exposed bedrock surfaces and karstic dissolution has progressed through joints, fractures and other porous zones into the subsurface. Dissolution-enhanced joints characterize karst development in the thick-bedded Amabel Formation dolostones on the topographically higher eastern side of the peninsula. Locally, in both the Amabel and Guelph formations, good clint and grike systems are developed. A joint-guided karstic cave system developed from near Tobermory to Little Cove, on the north shore, is described by Cowell (1976) as the longest active cave in Ontario. A typically pitted karstic

pavement is well developed on the bedding plane outcrops of western shore. In general, dissolution seems most intense in lithofacies with a higher fossil content and associated higher initial porosity (i.e. lithofacies A_c and G_d and the biostromal zones in lithofacies G_c.).

STRUCTURAL GEOLOGY

Liberty and Bolton (1971) report the regional dip of Paleozoic strata on the Bruce Peninsula to range from 4.8 to 7.6 m/km (25 to 40 feet per mile) to the southwest. A similar range of 5.5 to 6.2 m/km was determined for this map area using the base of the Fossil Hill Formation as a datum in OGS drill holes and outcrop elevations.

A well developed joint system is evident in the dolostone strata of the Bruce Peninsula. Locally, especially in the topographically higher and thick-bedded units on the eastern and northern parts of the peninsula, karst processes have preferentially dissolved joints up to 20 cm open. Although joint orientations were not systematically measured in this map area, general concentrations of orientations were noted. Most joint orientations measured fell into two main groups at 145 to 160° and 70 to 90° and two smaller groups at 45 to 70° and 135 to 145°. Generally joints were less well developed in biohermal strata.

Examination of false colour infra-red Landsat imagery of the Bruce Peninsula at the Ministry of Natural Resource's Ontario Centre for Remote Sensing revealed a number of lineaments oriented sub-parallel to the north shore of the peninsula. These lineaments reflect the linear arrangement wetlands, marshes, creeks and lakes. The orientation of these lineaments ranges from 70° in the area of McLander and Horseshoe marshes, south of Cyprus Lake, to 80° in the Umbrella and Lymburner lakes area. In each of these two areas there appears to be a set of at least three parallel lineaments spaced from 0.5 to 1.0 km apart.

The orientation of these lineaments is oblique to that of main glacial ice movement which was at approximately 220°. Although biohermal lithofacies occur in the general area of the lineaments, the lineaments do not appear to be directly associated with biohermal development. Also, the lineaments are of a much larger scale (kilometres long) as compared with the northwest trending biohermal ridges of the Amabel and Guelph formations which occur further to the south (south of Miller Lake, Lion's Head Promontory, and in the central part of the peninsula; Armstrong and Goodman 1990). Bathymetric charts for Georgian Bay reveal a large embayment immediately north of the Bruce Peninsula; this embayment contains the deepest point of the bay (560 ft or 170 m). Perhaps the lineaments are fractures created by stress release into this large embayment. The

approximate coincidence of the pinchout of the Wiarton/Colpoy Bay Member of the Amabel Formation with the this lineament zone suggests the possibilty that the lineaments mark the location of syn-sedimentary faults which controlled depositional patterns during the Silurian.

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MAPS
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